Digital Signal Processing for 100G/400G Optical Fiber Connectivity Links

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Digital Signal Processing for 100G/400G Optical Fiber Connectivity Links

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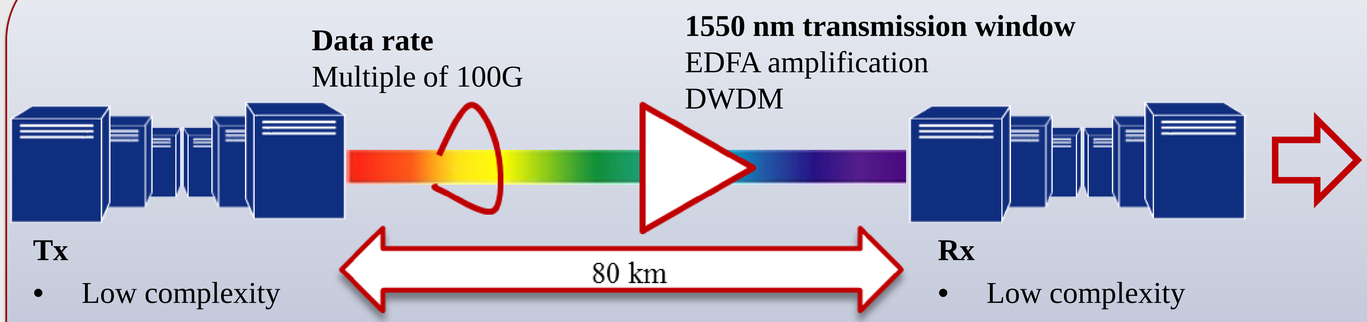
Motivation



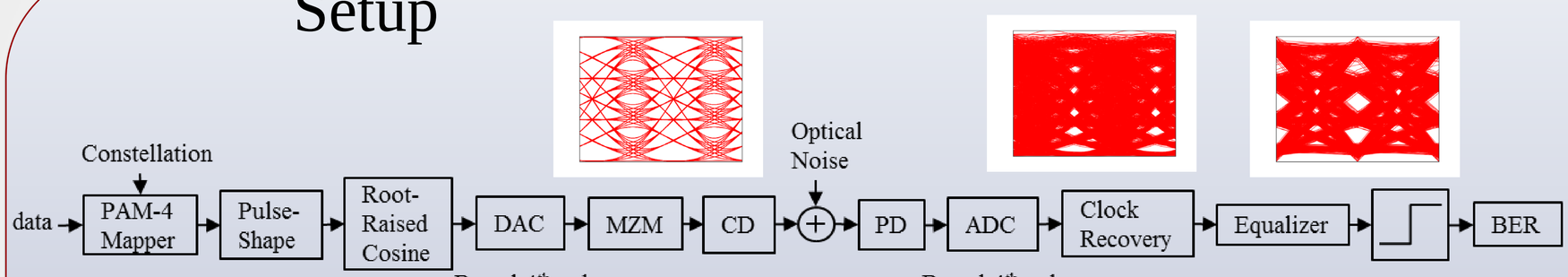
Tx
- Low complexity
- Low cost
- Low power consumption

Rx
- Low complexity
- Low cost
- Low power consumption

- **PAM-4** with direct detection is being considered as one of the most promising candidates for 100G and 400G data center interconnects.
- 400G solution:
  - Data rate of 56 Gb/s and 8 wavelength on a 50 GHz channel grid.
- Challenges with PAM-4 for this tranmission scenario:
  - Electrical and optical bandwidth limitation,
  - Chromatic dispersion.
- Here, we we investigate the performance of different equalizers experimentally and in simulations for 16 GBd PAM-4-transmission.

Numerical Investigation

Setup

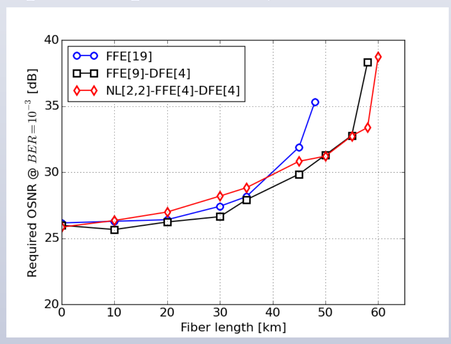


Simulation parameters:
- Data rate: 32 Gb/s (16 GBd)
- Gray Mapping
- Symbol period: 2048 Symbols (two deBruin sequences shifted by half the sequence length)
- 256 training-symbols
- DAC & ADC: infinite resolution
- Linear SSMF (D=17 ps/nm/km)

Different Equalizer (coefficient calculation is based on the MMSE-criterion):
- Feedforward Equalizer (FFE)
- FFE in combination with decision feedback equalizer (FFE-DFE)
- Nonlinear FFE-DFE based on the Volterra-Kernels (NL-FFE-DFE

Results

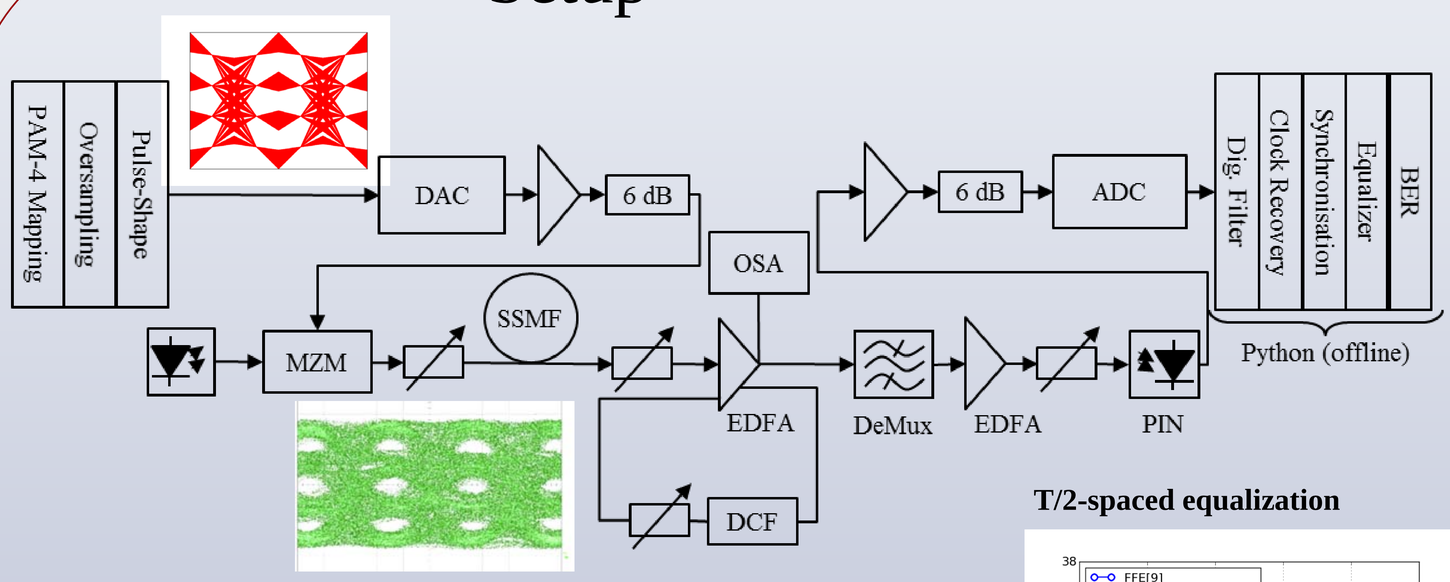
Dispersion Tolerance (T/2-spaced equalization)



- FFE-DFE shows an improvement over the FFE only for a longer transmission distance beyond 40 km
- The NL-FFE-DFE shows minor improvement over the FFE-DFE only beyond 55 km

Experimental Evaluation

Setup

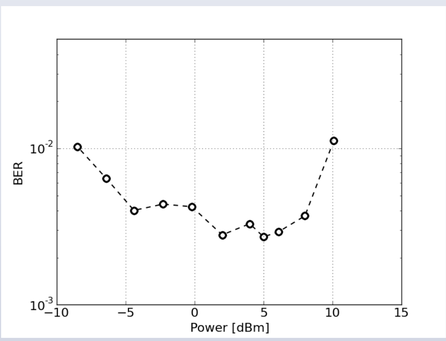


DSP
- Data rate: 32 Gb/s (16 GBd)
- Pulse Shaping with Root Raised Cosine
- Gray Mapping
- Period of 2048 PAM-4 symbols
- 256 training-symbols in order to train the equalizer at the beginning (static setup)

Hardware
- DAC, ADC: 64 GS/s
- MZM designed for 40 Gb/s
- SSMF with 0.18 dB/km attenuation
- Dual stage EDFA
- MUX: 100 GHz bandwidth
- PIN designed for 50 Gb/s

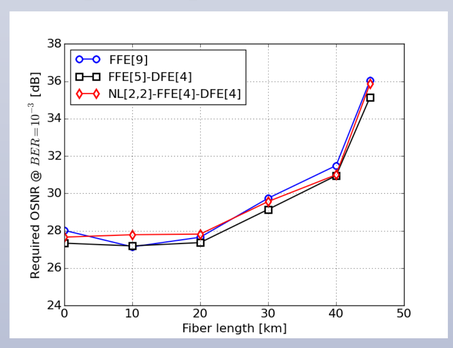
Results

Optimum Launch Power

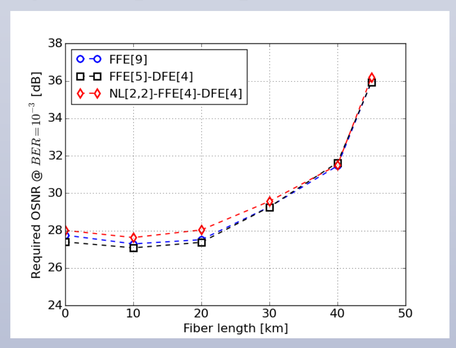


- Launch Power was set to 3 dBm

T/2-spaced equalization

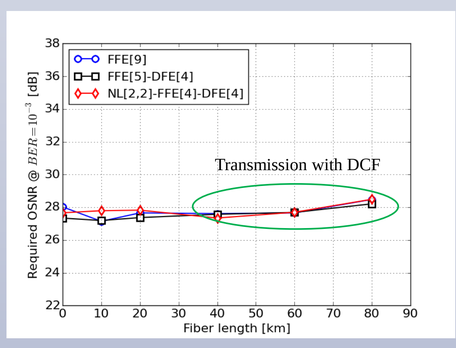


Symbol-spaced equalization



- No performance difference betwwen the different equalizer
- No performance difference between T/2-spaced and T-spaced equalization

Transmission with DCF



- No OSNR penalty observable with a DCF matched to the transmission length

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Conclusion

- The systems bandwidth limitation demand equalization.
- We did not observe any significant performance differences between FFE, FFE-DFE and NL-FFE-DFE for 16 GBd PAM-4 transmission.
- The considered transmission scenario does not require T/2-spaced equalization due to relatively narrow system bandwidth, thus saving computational complexity.
- 16 GBd PAM-4 transmission over up to 80 km with DCF in the 1550 nm transmission window was shown without any OSNR-penalty
- Further investigations are necessary to enable a transmission of 28 GBd PAM-4 with this transmission system in order to be a solution for the next generation of data center interconnects.